

I CLAIM:

1. An external combustion cool gas generator comprising:
 - a first storage tank configured to contain a high-pressure liquid propellant;
 - a second storage tank configured to contain a reactive chemical;
 - a combustion chamber connected to the second storage tank and configured to chemically react the reactive chemical to form a hot product gas at a pressure substantially lower than a pressure of the high-pressure liquid propellant;
 - a nozzle having a melting temperature;
 - a heat exchanger connected to the first storage tank at a first end and connected to the nozzle at a second end, the heat exchanger configured to plumb the high-pressure liquid propellant from the first storage tank to the nozzle, wherein the heat exchanger is connected to the combustion chamber so that heat from the hot product gas is transferred to the high-pressure liquid propellant through heat-conducting walls of the heat exchanger to thereby raise a temperature of the high-pressure liquid propellant to substantially gasify the high-pressure liquid propellant,
 - wherein the nozzle is configured to expel the substantially gasified high-pressure liquid propellant from the gas generator and, during the expulsion, to expand the substantially gasified high-pressure liquid propellant, and
 - wherein the gas generator is configured so that an expansion temperature of the substantially gasified high-pressure liquid propellant to be expanded by the nozzle is substantially lower than the melting temperature.
2. The gas generator as in claim 1, wherein the gas generator is configured so that the expansion temperature is in the range 0°C to 100°C.
3. The gas generator as in claim 1, further comprising a first valve configured to be capable of substantially continuously adjusting a flow rate of the high-pressure liquid propellant to the nozzle.

4. The gas generator as in claim 1, further comprising a second valve configured to be capable of substantially continuously adjusting a flow rate of the hot product gas through the heat exchanger.

5. The gas generator as in claim 1, wherein the gas generator is a rocket engine,

wherein the nozzle has an expansion ratio of at least 3,

wherein the nozzle is configured to expel the substantially gasified high-pressure liquid propellant substantially in one direction, and

wherein the expulsion of the substantially gasified high-pressure liquid propellant causes an impulse reaction on the rocket engine in an opposite direction.

6. A cool gas generator comprising:

a first storage tank configured to contain a high-pressure liquid propellant;

a nozzle connected to the first storage tank;

a heat source connected between the first storage tank and the nozzle and configured to add heat to the high-pressure liquid propellant at a heat transfer rate to substantially gasify the high-pressure liquid propellant, wherein the nozzle is configured to expel the substantially gasified high-pressure liquid propellant from the gas generator and, during the expulsion, to expand the substantially gasified high-pressure liquid propellant, and wherein the gas generator is configured so that an expanded temperature of the substantially gasified high-pressure liquid propellant after being expanded by the nozzle is in the range -50°C to 100°C; and

a controller connected to the heat source and configured to adjust the heat transfer rate.

7. The gas generator as in claim 6, wherein the expanded temperature is in the range 0°C to 50°C.

8. The gas generator as in claim 6, wherein the nozzle has a melting temperature,

wherein the gas generator is configured so that an expansion temperature of the substantially gasified high-pressure liquid propellant to be expanded by the nozzle is substantially lower than the melting temperature,

wherein the gas generator further comprises a temperature sensor connected to the controller and configured to measure the expansion temperature, and

wherein the controller is configured to adjust the heat transfer rate based on the expansion temperature so as to adjust the expansion temperature to a target expansion temperature.

9. The gas generator as in claim 6, wherein the high-pressure liquid propellant comprises: a liquid that, at room temperature, has a vapor pressure substantially greater than 1 atm; and a decomposable chemical that decomposes upon reaction with a catalyst, and

wherein the heat source comprises the catalyst.

10. The gas generator as in claim 6, wherein the heat source comprises: a second storage tank configured to contain a reactive chemical; a combustion chamber connected to the second storage tank and configured to chemically react the reactive chemical to form a hot product gas, and

wherein the heat source is configured to mix the high-pressure liquid propellant with the hot product gas.

11. The gas generator as in claim 10, wherein substantially all of the hot product gas formed by the heat source remains a gas at the expanded temperature.

12. The gas generator as in claim 10, wherein a composition of the high-pressure liquid propellant and a composition of the hot product gas is substantially the same.

13. The gas generator as in claim 6, wherein the heat source comprises: a second storage tank configured to contain a reactive chemical; and a combustion chamber

connected to the second storage tank and configured to chemically react the reactive chemical to form a hot product gas,

wherein the controller comprises a valve to adjust the heat transfer rate from the hot product gas to the high-pressure liquid propellant, and

wherein the gas generator is configured to be air-breathing, such that the reactive chemical is chemically reactive with air and the combustion chamber is configured to combust the reactive chemical with the air.

14. The gas generator as in claim 6, wherein the gas generator is a rocket engine,

wherein the nozzle has an expansion ratio of at least 3,

wherein the nozzle is configured to expel the substantially gasified high-pressure liquid propellant substantially in one direction, and

wherein the expulsion of the substantially gasified high-pressure liquid propellant causes an impulse reaction on the rocket engine in an opposite direction.

15. An external combustion cool gas generator comprising:
means for providing a high-pressure liquid propellant;
a nozzle connected to the means;
a first heat source;
a first heat exchanger connecting the first heat source to at least one of the means and the nozzle so that heat from the first heat source is transferred to the high-pressure liquid propellant through heat-conducting walls of the first heat exchanger to thereby gasify the high-pressure liquid propellant;
a second heat source; and
a second heat exchanger connecting the second heat source to at least one of the means and the nozzle so that heat from the second heat source is transferred to the gasified high-pressure liquid propellant to thereby raise a temperature of the gasified high-pressure liquid propellant above a temperature of the high-pressure liquid propellant,

wherein the nozzle is configured to expel the gasified high-pressure liquid propellant from the gas generator and, during the expulsion, to expand the gasified high-pressure liquid propellant.

16. The gas generator as in claim 15, wherein the gas generator is configured so that an expanded temperature of the substantially gasified high-pressure liquid propellant after being expanded by the nozzle is in the range 0°C to 50°C.

17. The gas generator as in claim 15, further comprising a nozzle valve configured to be capable of substantially continuously adjusting a flow rate of the gasified high-pressure liquid propellant to the nozzle,

wherein the nozzle valve is configured to regulate a pressure inside the means to a threshold operating pressure, such that: a) when the pressure is less than the threshold operating pressure, the valve is closed; and b) when the pressure rises above the threshold operating pressure, the valve variably opens as a function of the pressure, so that the pressure does not rise to substantially greater than the threshold operating pressure.

18. The gas generator as in claim 15, wherein at least one of the first and second heat sources comprises: a storage tank configured to contain a reactive chemical; and a combustion chamber configured to chemically react the reactive chemical to form a hot product gas at a pressure substantially lower than a pressure of the high-pressure liquid propellant,

wherein the gas generator further comprises a nozzle valve configured to be capable of adjusting a flow rate of the gasified high-pressure liquid propellant to the nozzle, and

wherein the first heat exchanger comprises a first valve configured to be capable of adjusting a flow rate of the hot product gas through the first heat exchanger, and the second heat exchanger comprises a second valve configured to be capable of adjusting a flow rate of the hot product gas through the second heat exchanger.

19. The gas generator as in claim 15, wherein the nozzle is configured to expel substantially only the substantially gasified high-pressure liquid propellant.

20. The gas generator as in claim 15, wherein the gas generator is a rocket engine,

wherein the nozzle has an expansion ratio of at least 3,

wherein the nozzle is configured to expel the gasified high-pressure liquid propellant substantially in one direction, and

wherein the expulsion of the gasified high-pressure liquid propellant causes an impulse reaction on the rocket engine in an opposite direction.